

# **The Tree of Life: Analyzing Descent with Modification**

## **Why?**

Evolutionary theory is often called the “grand unifying theory of the life sciences”. Even though Darwin’s mechanism of natural selection is confirmed again and again by data, modern scientists try to “fill in the holes” by researching some of the finer points of the natural selection. Does evolution always occur at the same rate? How does modern biology explain variation? How can the data presented by evolutionary theory be used to create a better classification system? These questions and more are fodder for current research in evolutionary biology.

## **Learning Objectives**

Students will:

- Identify species that are closely related on a phylogenetic tree.
- Identify extinct species on a phylogenetic tree
- Identify ancestral species on a phylogenetic tree
- Explain the difference between gradualism and punctuated equilibrium

## **Prerequisites and Resources**

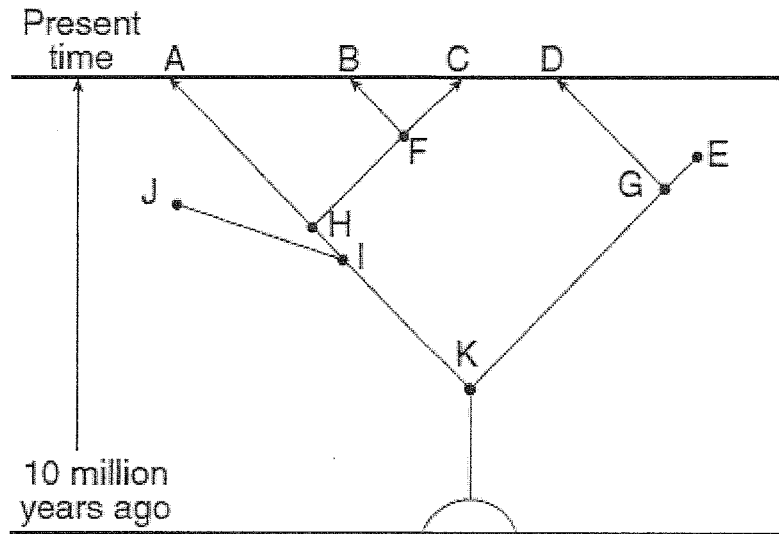
- Graphs have an X and Y axis
- Extinct species are no longer present on our planet
- Natural selection implies common descent
- The sources of evidence for evolution

## **Concepts/Vocabulary**

- Phylogenetic tree
- Punctuated equilibrium
- Gradualism

## Model 1

Darwin's ideas about natural selection and descent with modification have given rise to the study of *phylogeny*, or evolutionary relationships between organisms. Using the evidence gathered from evolutionary studies, scientists use phylogenetic trees to illustrate these relationships. These trees work very much like a family tree you may draw when studying your genealogy. In the phylogenetic tree below, the letters each represent a distinct species.



### Key Questions

1. What units are used on the y-axis of this chart?
2. What do the letters in the phylogenetic tree represent?
3. List the four species you might be able to see today. Explain your reasoning.
4. According to information in the diagram, why would you not expect to see species "J" in a zoo?

5. Species "B" and "C" are closely related. How could you tell this from the phylogenetic tree?

6. What species is the ancestor of all of the others on this diagram? Explain how you can tell from the diagram.

7. Explain **how** species "H" could have given rise to species "A", "B", and "C" in terms of natural selection.

8. What types of evidence could be used to create the phylogenetic tree?

1.

2.

3.

9. Provide an example of how this diagram could be useful/important.

## Model 2

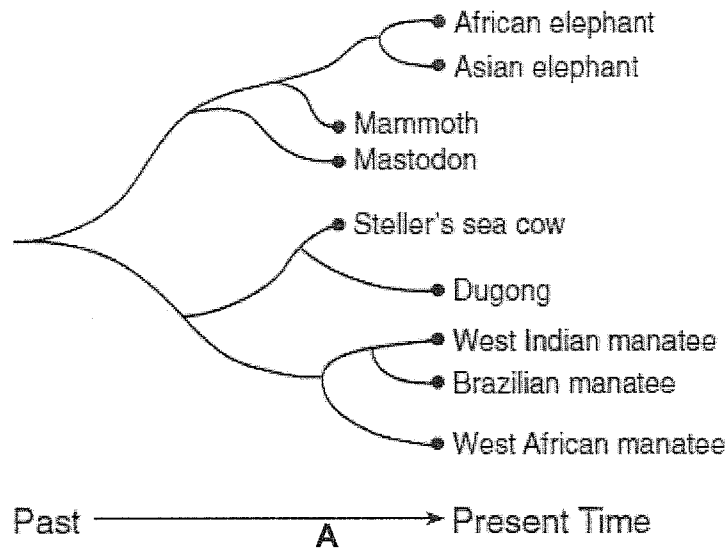


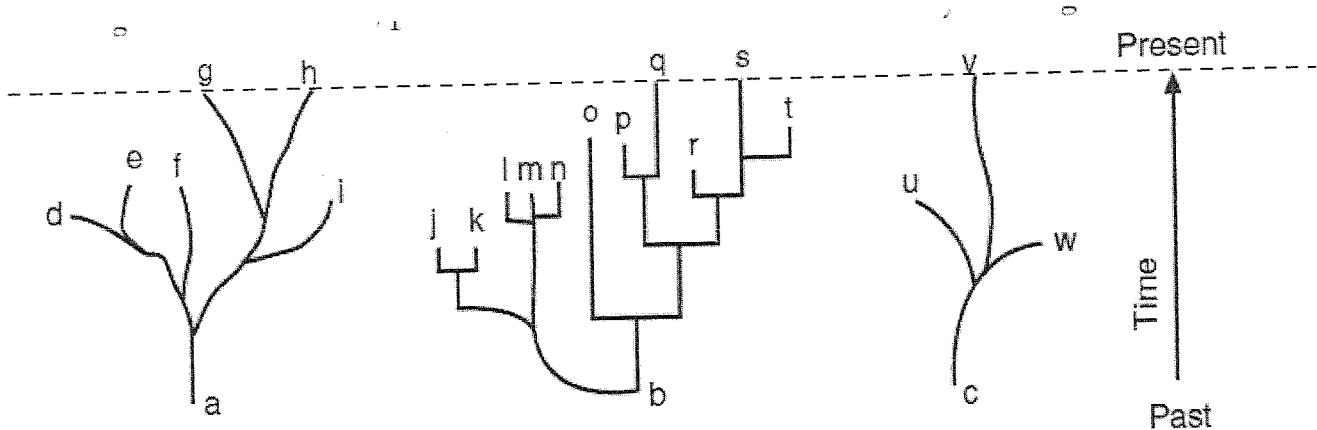
Figure 2: Possible phylogenetic tree.

### Questions:

1. What is represented by the x-axis?
2. List two species that are alive today.
3. Explain how you can tell from the diagram that the Mastodon is extinct.
4. Who is more closely related the Asian and African Elephants or the West Indian Manatee and the West African Manatee? Explain your reasoning.
5. Look at time point "A". Give a hypothesis as to what have occurred in the environment at this point in history.

### Model 3

The following diagrams represent the phylogenetic trees for three different groups of organisms listed as "a", "b" and "c".



### Key Questions

1. What species is the ancestor of "U", "V", and "W"?
2. List all species that are alive today.
3. Out of the four species that are currently alive today, which 2 are most closely related? How can you tell?
4. Identify one extinct species who descended from species "A"
5. According to Darwin, the fossil record indicates that species evolve **gradually**. In other words, biological change was slow and steady over time. Which tree above (a, b, or c) best illustrates this concept of gradualism? Explain your reasoning.

6. There is evidence that the slow and steady pace of gradualism is not always corroborated in the fossil records. Some species seem to have long periods of no change called equilibrium. These long periods of equilibrium are then followed by short, rapid bursts of change. Scientists call this ***punctuated equilibrium***. Which tree above (a, b, or c) best illustrates this concept of punctuated equilibrium? Explain your reasoning.

## Practice Questions

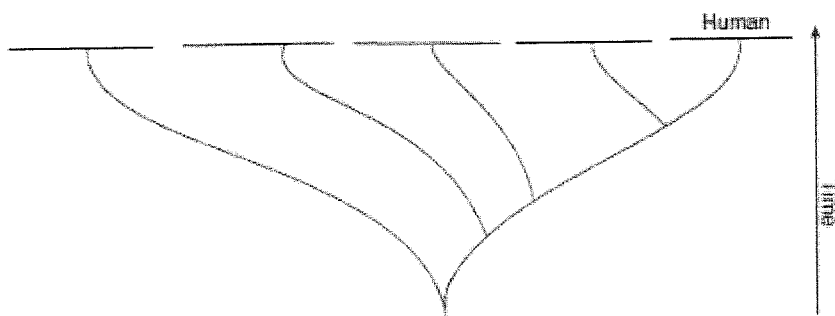
## Problems

- 60 The data table below shows the number of amino acid differences in the hemoglobin molecules of several species compared with amino acids in the hemoglobin of humans.

Amino Acid Differences

Species	Number of Amino Acid Differences
human	0
frog	67
pig	10
gorilla	1
horse	26

Based on the information in the data table, write the names of the organisms from the table in their correct positions on the evolutionary tree below. [1]



Provide an explanation as to why you placed the names as you did.

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Base your answers to the following questions on the chart below.

Species	Sequence of Four Amino Acids Found in the Same Part of the Hemoglobin Molecule of Species
human	Lys–Glu–His–Phe
horse	Arg–Lys–His–Lys
gorilla	Lys–Glu–His–Lys
chimpanzee	Lys–Glu–His–Phe
zebra	Arg–Lys–His–Arg

1. Which two organisms in this chart are most closely related? Explain your thinking.
2. How many amino acid differences are there between the gorilla and the chimpanzee? \_\_\_\_\_
3. How many amino acid differences are there between the gorilla and the horse? \_\_\_\_\_
4. Using the information in the chart, create your own phylogenetic tree to illustrate the relationship between the organisms in this data table.